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Quantum electrodynamic approach to the conductivity of gapped graphene

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Abstract

©2016 American Physical Society.The electrical conductivity of graphene with a nonzero mass-gap parameter is investigated starting from the first principles of quantum electrodynamics in (2+1)-dimensional space time at any temperature. The formalism of the polarization tensor defined over the entire plane of complex frequency is used. At zero temperature we reproduce the results for both real and imaginary parts of the conductivity, obtained previously in the local approximation, and generalize them taking into account the effects of nonlocality. At nonzero temperature the exact analytic expressions for real and imaginary parts of the longitudinal and transverse conductivities of gapped graphene are derived, as well as their local limits and approximate expressions in several asymptotic regimes. Specifically, a simple local result for the real part of conductivity of gapped graphene valid at any temperature is obtained. According to our results, the real part of the conductivity is not equal to zero for frequencies exceeding the width of the gap and goes to the universal conductivity with increasing frequency. The imaginary part of conductivity of gapped graphene varies from infinity at zero frequency to minus infinity at the frequency defined by the gap parameter and then goes to zero with further increase of frequency. The analytic expressions are accompanied by the results of numerical computations. Possible future generalization of the used formalism is discussed.

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